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(54) Process for depositing tantalum oxide film and chemical vapor deposition system used therefore.

(57) A process of depositing a tantalum oxide film starts with preparing a reactor (34) with a vacuum chamber (35) associated with a plasma generating unit (32), a tantalum chloride gas and an oxygen-containing gas such as a dinitrogen monoxide gas are supplied to the vacuum chamber, and a plasma is produced in the vacuum chamber for plasma-assisted chemical reactions; a tantalum oxide film thus deposited decreases leakage current passing therethrough because the chemical composition thereof is close to the stoichiometry and undesirable pin holes and impurities are reduced.

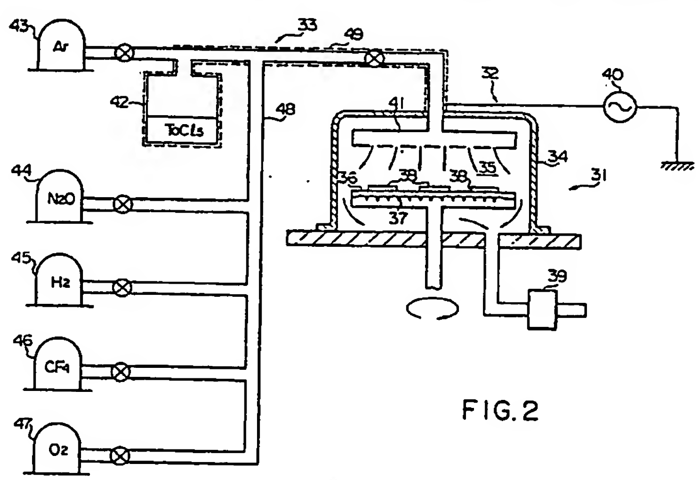

FIG.2

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presented by the molecular formula of N_2O, a nitrogen oxide gas represented by the molecular formula of NO and an oxygen gas represented by the molecular formula of O_2, and c) producing a plasma in the vacuum chamber so that plasma-assisted chemical reactions take place for a tantalum oxide.

In accordance with another aspect of the present invention, there is provided a chemical vapor deposition system for producing a tantalum oxide conprising a) a reactor unit having a vacuum chamber, b) a gas source unit coupled to the vacuum chamber for supplying a gaseous mixture containing a tantalum chloride and an oxygen-containing gas selected from the group consisting of a dinitrogen monoxide represented by the molecular formula of N_2O, a nitrogen oxide gas represented by the molecular formula of NO and an oxygen gas represented by the molecular formula of O_2, and c) a plasma generating unit producing a plasma in the gaseous mixture in the vacuum chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of a process and a system according to the present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic view showing the arrangement of a prior art chemical vapor deposition system;

Fig. 2 is a schematic view showing the arrangement of a chemical vapor deposition system according to the present invention;

Figs. 3A to 3C are cross sectional views showing a part of a process sequence for fabricating a semiconductor device; and

Fig. 4 is a graph showing the amount of leakage current in terms of the strength of electric field produced across the tantalum oxide films.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to Fig. 2 of the drawings, a chemical vapor deposition system according to the present invention largely comprises a reactor unit 31, a plasma generating unit 32 and a gaseous mixture supplying unit 33.

The reactor unit 31 has a reactor 34 with a vacuum chamber 35, and a wafer holder 36 accompanied with a heating element 37 projects into the vacuum chamber 35 for retaining semiconductor wafers 38.

Each of the semiconductor wafers 38 has an intermediate structure on the way to an integration of semiconductor devices, and is, by way of example, implemented by a silicon substrate 38a partially covered with a silicon dioxide film 38b which in turn is partially covered with a phosphorus-doped polysilicon film 38c for a lower capacitor elec trode connected through contact holes 38f formed in the silicon dioxide film 38b to the substrate 38a as shown in Fig. 3A.

The vacuum chamber 35 is coupled to a vacuum pump unit 39 so that gaseous mixture is continuously evacuated from the vacuum chamber 35.

The plasma generating unit 32 has a high frequency electric power source 40 and is operative to produce plasma for promoting chemical reactions in the gaseous mixture.

The gaseous mixture supplying unit 33 has a gas outlet 41 projecting into the vacuum chamber 35, a vaporizer 42 for tantalum chloride ($TaCl_5$), an argon gas source 43, a dinitrogen monoxide gas source 44, a hydrogen gas source 45, a carbon tetrafluoride gas source 46, an oxygen gas source 47, a pipe network 48 with valve units selectively interconnecting the vaporizer 42, the gas sources 43 to 47 and the reactor 34, and a heating system 49 for the vaporizer 42 as well as the pipe network 48. The argon gas conducted into the vaporizer 42 serves as a carrier gas for conveying the tantalum chloride gas into the vacuum chamber 35.

A chemical vapor deposition process according to the present invention starts with vaporizing the tantalum chloride. Namely, the heating system 49 supplies heat to the tantalum chloride in the vaporizer 42, and the argon gas is guided from the source 43 into the vaporizer 42. The argon gas flow is about 10 sccm to about 200 sccm at 0.1 torr to 10.0 torr. The vaporized tantalum chloride is carried on the argon gas, and the gaseous mixture thereof is conducted toward the vacuum chamber 35. The dinitrogen monoxide gas is supplied from the source 44 to the pipe network 48, and is mixed into the gaseous mixture on the way to the vacuum chamber 34. In this instance, vaporizer 42 and the pipe between the vaporizer 42 and the reactor 34 are heated at about 50 degrees to about 200 degrees in centigrade, and the dinitrogen monoxide gas is regulated to about 0.1 SLM to about 5.0 SLM. The gaseous mixture containing the tantalum chloride, the argon and the dinitrogen monoxide flows into the vacuum chamber by the agency of vacuum created therein.

The heating element 37 increases the wafer holder 36 and, accordingly, the semiconductor wafers 38 in temperature, and the high frequency electric power source 40 allows plasma to be produced in the gaseous mixture containing the tan-

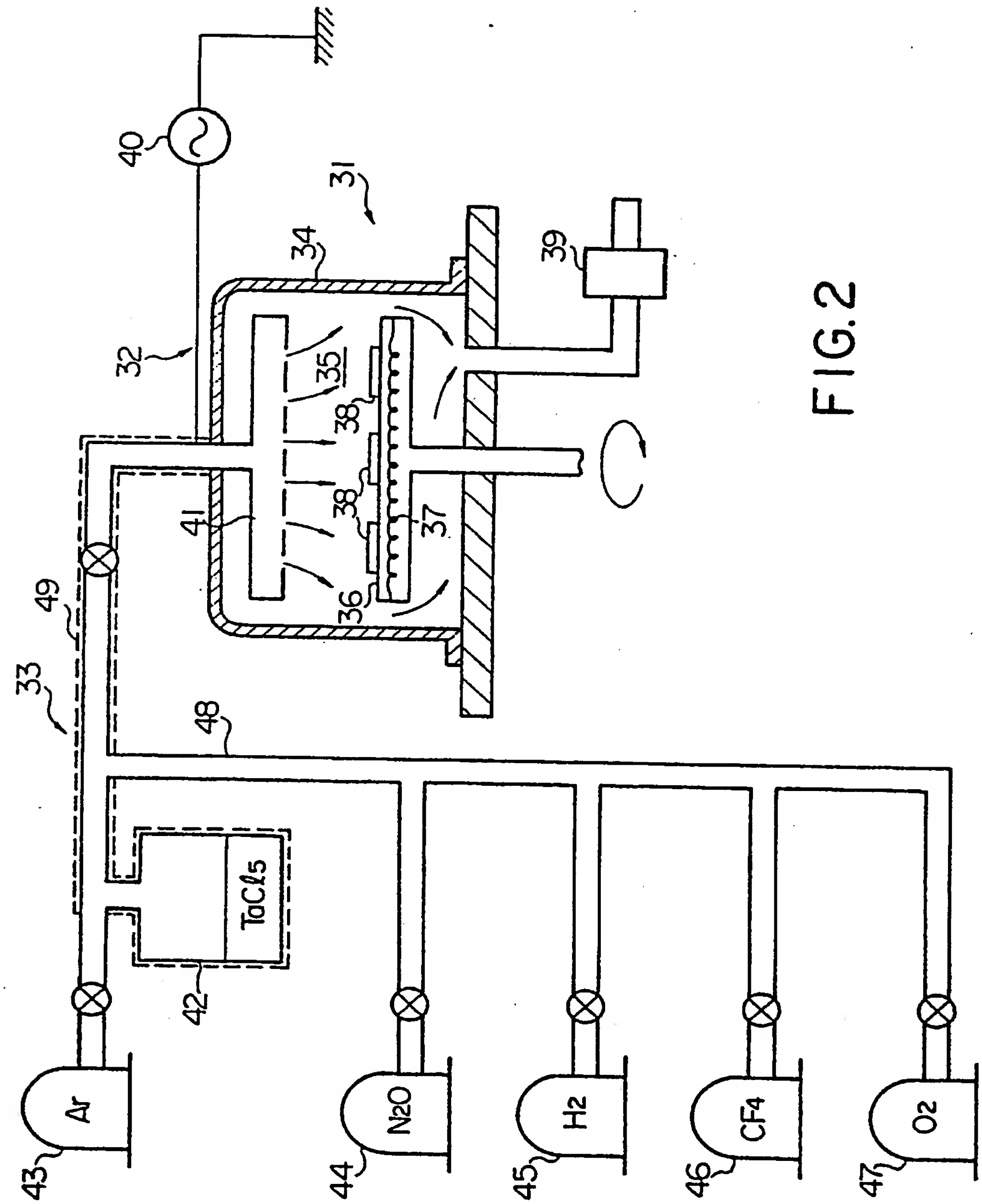
part of a capacitor. Moreover, the plate electrode 38e may be formed of a refractory metal silicide film except for the tungsten silicide, a polysilicon film, a polyside film, or a metallic nitride film such as a tungsten nitride film.

Claims

1. A process of depositing a tantalum oxide film comprising the steps of a) preparing a reactor with a vacuum chamber associated with a plasma generating unit, and b) supplying a gaseous mixture containing tantalum compound to said vacuum chamber, characterized in that said gaseous mixture contains a tantalum chloride ard an oxygen-containing gas selected from the group consisting of a dinitrogen monoxide represented by the molecular formula of N_2O, a nitrogen oxide gas represented by the molecular formula of NO and an oxygen gas represented by the molecular formula of O_2, and in that said process further comprises the step of c) producing a plasma in said vacuum chamber so that plasma-assisted chemical reactions take place for a tantalum oxide.

2. A process as set forth in claim 1, in which said oxygen-containing gas is said dinitrogen monoxide gas.

3. A chemical vapor deposition system for producing a tantalum oxide comprising a) a reactor unit having a vacuum chamber, b) a gas source unit coupled to said vacuum chamber for supplying a gaseous mixture, characterized in that said gaseous mixture contains a tantalum chloride and an oxygen-containing gas selected from the group consisting of a dinitrogen monoxide represented by the molecular formula of N_2O, a nitrogen oxide gas represented by the molecular formula of NO and an oxygen gas represented by the molecular formula of O_2, and in that said chemical vapor deposition system further comprises c) a plasma generating unit for producing a plasma in said gaseous mixture in said vacuum chamber.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TaCl5
Ar
N2O
H2
CF4
O2

FIG.2

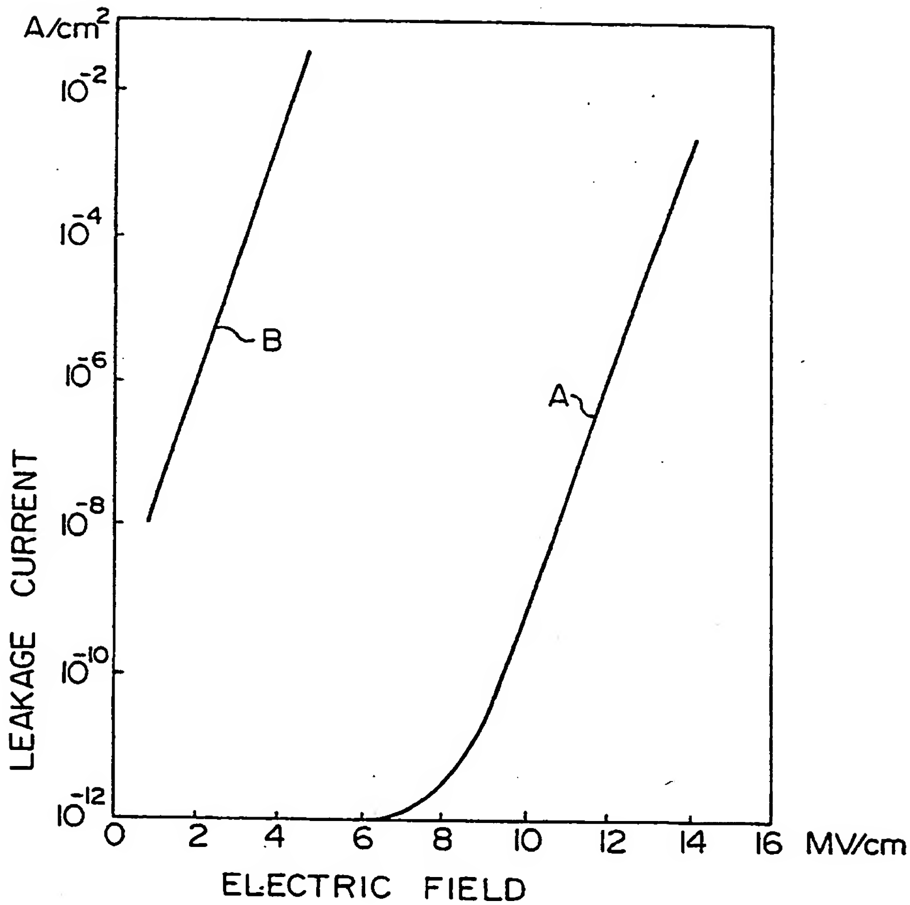
A/cm²
10⁻²
10⁻⁴
10⁻⁶
10⁻⁸
10⁻¹⁰
10⁻¹²
LEAKAGE CURRENT
B
A
0
2
4
6
8
10
12
14
16
MV/cm
ELECTRIC FIELD

FIG. 4